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Kaolin Improves Photosynthetic Pigments, and Antioxidant Content, and Decreases Sunburn of Mangoes: Field Study

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Abstract: The Keitt mango tree has a low canopy that leads to an increase in sunburned fruits. Hence, the fruit quality is markedly reduced due to the fruit being exposed to physiological disorders. The sunburn injury problem is common due to high levels of solar radiation and the low number of leaves, which minimizes the protection of small, newly formed fruits. Kaolin spray has emerged as a promising approach for mango trees since it improves vegetative growth, yield, and fruit quality in new lands. This search aimed to study the influence of spraying kaolin on Keitt mango trees grafted on 'Succary' rootstock. The treatments were as follows: control, 2%, 4%, and 6% of kaolin. Our results indicated that the applications of kaolin significantly improved leaf area, tree canopy volume, photosynthesis pigments such as chlorophyll-a and b, carotenoids of leaf and yield (kg/tree), and the physical and chemical characteristics of Keitt mango cultivar in comparison with the control. A higher concentration of kaolin decreased the leaf content of antioxidants such as total phenolic, total flavonoid, CAT, POX, and PPO enzyme activities. Furthermore, the number of sunburned fruits was significantly reduced after the application of kaolin in comparison to control fruits. Regarding vegetative growth, our results indicated that adding kaolin at 6% enhanced the leaf surface area and tree canopy volume compared to the control and other treatments. A similar trend was noticed regarding yield and fruit quality, whereas the best values were obtained when kaolin was sprayed at a concentration of 6%. In conclusion, the application of kaolin can improve the production and fruit quality of Keitt mango trees by reducing the effects of adverse summer conditions.

Keywords: *Mangifera indica* L.; mango; kaolin; sunburn; fruit quality; yield increasing; vitamin C

1. Introduction

Mango (*Mangifera indica* L.) is widely grown in irrigated, semi-arid regions worldwide [1]. Mango fruit is high in vitamins and minerals and is known for its delicious flavor, appealing smell, and nutritious value [2]. The mango-planted area in Egypt is ranked

second in the world for fruit crop acreage. Moreover, the Keitt mango has been successfully grown. Moreover, the mango growers in Egypt have claimed that the Keitt mango productivity is one of the most important late-season varieties [3]. Keitt mangoes ripen in Florida from September to October [4]. However, the Keitt mango cultivar growth habit has fewer leaves compared to other mango cultivars, and Egypt's climate has high solar radiation. Fruits that have been subjected to specific physical and physiological problems have lower quality and marketability [3].

Sunburn is a common occurrence on fruits due to high levels of solar radiation and air temperatures, low relative humidity, and high elevations, as well as the low number of leaves that protect small, freshly formed fruits [5]. The occurrence and severity of sunburn are influenced by the environment, species, hormonal status, mineral nutrition, and soil moisture [6]. Sunburn can reduce fruit yield by 6% to 30%, depending on the growing season and the type of fruit tree [7–9]. Mango growers should practice proper management practices to reduce sunburn and produce sun-tolerant varieties. Furthermore, they have protected their mango trees from abiotic stress, pruning trees with suitable canopy volume, cultivating cover cropping or intercropping, establishing over-tree sprinkler systems, netting, fruit bagging, and adding suppressants (calcium carbonate or kaolin) and chemical protectants [3,10].

For the protection of agricultural plants against abiotic stress, Kaolin has two modes of action [11]. The first is a visible particle layer that reflects harmful U.V. and I.R. radiation while lowering the plant's temperature [9]. The second is a naturally occurring chemical that activates all crop plants' intrinsic stress response systems [12]. A noticeable whitish film forms when kaolin is applied to plants [3]. A full, uniform, and constant covering throughout the stress phase is required for optimal performance [13]. A screen pair may improve plant vigor, total yield, and quality [12]. When the temperature outside is hot, kaolin lowers the canopy temperature, decreasing heat, light, and water stress [14]. Fruit quality, such as total soluble solids and fruit size, improves when stress is reduced [3]. Improved color, decreased fruit drop, sunburn, and cracking are among the other advantages [12–14]. Kaolin reflects harmful rays and heat while allowing photosynthesis and the uptake of nutrients and crop protection products [12]. Kaolin (clay) is a natural substance with kaolinite ($Al_2Si_2O_5(OH)_4$) as its major ingredient. Kaolin foliar spray has been effectively used on a variety of fruit tree species to reduce sunburn and improve yield as well as the physical and chemical qualities of the fruit [15–17]. Because of their potential to affect the microclimate of the plant canopy, kaolin-based particle films can minimize insect, heat, and ultraviolet stress in horticultural crops [15]. Kaolin treatments significantly reduced the temperature of apple fruits compared with the control [17]. Kerns and Wright [15] reported that kaolin application on lemon trees lowered the temperature of the fruit surface, reduced sun injuries, and improved yield and fruit quality. Ennab et al. [18] mentioned that kaolin foliar spraying at concentrations of 3% and 4% decreased leaf heat and fruit surface temperature and reduced the number of sunburned fruits of 'Balady' mandarin trees. Baiea et al. [3] found that kaolin foliar spray at concentrations of 25.5 and 75 g/L reduced fruit sunburn damage and improved the yield and fruit quality of Keitt mango fruits. Hagagg and his co-workers [19] reported that spraying kaolin and calcium carbonate at a concentration of 7% improved the vegetative growth parameters of the olive cultivar. Mohsen and Ibrahim [20] reported that kaolin treatment reduced both fruit sunburn and blotch of Murcott tangerine trees compared to untreated trees. Nowadays, many growers are required to alleviate the adverse impacts of high solar radiation. Treatments of reflective material are the most crucial technique. This application minimizes abiotic stress (heat, light, and water deficit) in fruit trees by reflecting solar radiation from the canopy surface of trees [21–24]. The main goal of this study was to elucidate new agronomic approaches, such as kaolin (commercial kaolin clay) spray, which can improve the growth of the tree canopy, yield, and fruit quality by reducing fruit sunburn damage under Egypt's environmental conditions and its effects on physiological and biochemical characteristics.

2. Materials and Methods

2.1. Experimental Site

This study was carried out in the private orchard located at Wady Elmoullak, El-Sharkia Governorate, Egypt (30°26′16.8″ N, 31°46′37.92″ E altitude 115 m). The average monthly precipitation and temperature from 2020 to 2021 are presented in Figure 1.

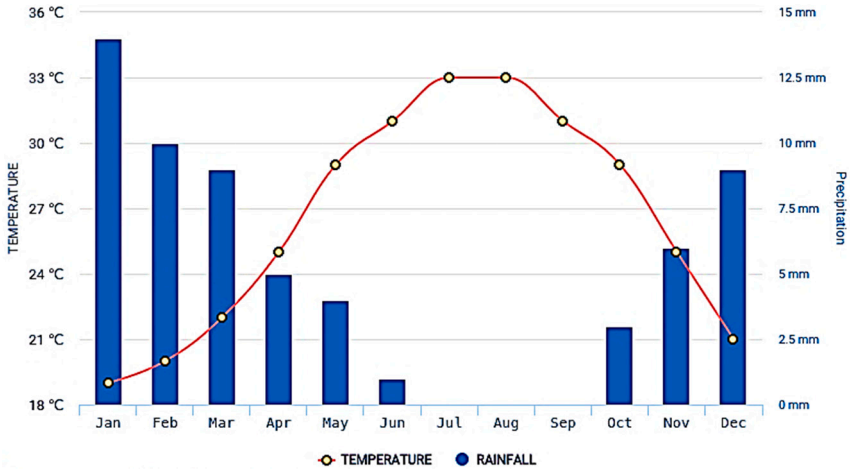


Figure 1. The average monthly temperature and precipitation during the growing season.

2.2. Experimental Design

This work was conducted from January 2020 to November 2021. Three replications (9 trees for each kaolin concentration) were designed according to the randomized block experimental design by forming four treatments comprising four different kaolin levels. The trees were sprayed with the kaolin (0%, 2%, 4%, and 6%) three times (15 June, 15 July, and 15 August) during the study. Moreover, the treatments were applied on the same days in both seasons. The kaolin material, with 3 L of suspension sprayed per tree, uniformly covered the leaves of the experimental trees. All sprayed solutions, including control (0%), contained 0.1% of tween 20 as detergent to improve adhesion to the leaf surface. The Keitt mango cultivar was planted in 2011 after grafting onto 'Succary' rootstock. The trees were planted 2 × 3 m apart (700 trees/fed), and surface methods of drip irrigation were used in the research farm with eight adjustable discharge emitters/trees (8 litter/h) through 2 irrigation lines. The region's climate is the Mediterranean, with an annual average temperature of 21.3 °C and an annual rainfall of 26 mm. Before the beginning of the first season (2020), a physical and chemical analysis of the orchard soil surface (40 cm depth) was determined according to [25], as shown in Table 1 below. The soil of the studied area is sandy with 94.53% sand (Table 1).

Table 1. Physical and chemical properties of the experimental farm soil.

Soil Physical Analysis				EC (ds/m)	pH	Soil Chemical Analysis							
Sand (%)	Silt (%)	Clay (%)	Soil Texture			Cations (meq/L)				Anions (meq/L)			
						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	So_4	Cl^{-}	HCo_3	Co_3
93.53	4.22	2.25	Sand	0.46	7.20	2.00	0.94	1.24	0.21	0.48	1.87	2.00	0.00

The Keitt mango trees also received the recommended fertilization program (130 N, 35 P_2O_5, and 90 K_2O kg/feddan/year). The micronutrient was applied as a mixture of 300, 150, 100, 50 and 50 mg of the applied fertilizer from chelated Fe, Mn, Zn, Cu, and B as boric acid, respectively, in March, May, and August.

2.3. Field and Laboratory Determinations

Vegetative Growth

Tree canopy volume (m^3). Tree size, known as a canopy volume, was calculated by the formula of [26], as follows: 0.52 × tree height × (diameter^2).

For the leaf area (cm^2): A sample of ten mature leaves per tree was abscised at the cessation of growth in December, then leaf area (cm^2) was calculated according to the equation of [27] as follows:

Leaf area = 0.70 (L × W) – 1.06 = … … … cm^2, where: L and W = maximum leaf length and width, respectively.

2.4. Biochemical Characteristics of Leaf

Ten mature leaves/tree samples (the fifth distal leaf on the labeled shoot), according to El Kheshin 2016 (No.), were collected in an ice box tank on the first week of September and, thereafter, stored in the freezer until determining the following biochemical contents in leaf:

2.4.1. Photosynthetic Pigments

Photosynthetic pigments, such as chlorophyll a, chlorophyll b, total chlorophyll and total carotenoids, were extracted from fresh leaves of the Keitt mango cultivar by homogenizing fresh leaves (0.2 g) with 10 mL of acetone (80% v/v) followed by centrifuging at 12,000× g for 10 min. A total of 3 mL of the liquid extract was used for analyses by spectrophotometry according to Brito et al. [28], and the results were calculated according to Wellburn, 1994 [29].

2.4.2. Antioxidant Enzyme Activity

For CAT, POX and PPO enzymes extraction from fresh leaves of Keitt mango cultivar, fresh leaves (0.5 g) were homogenized in a mortar containing 5 mL of 0.1 M cold phosphate buffer (pH 7.1) and centrifuged at 15,000× g for 20 min at 4 °C. The supernatant was used for enzyme activity assay [29]. The enzyme activity of catalase (CAT) was measured according to [30]. Peroxidase activity (POX) was assayed according to Esfandiari and Sabaghnia [31]. Polyphenol oxidase (PPO) activity was measured according to Esfandiari and Sabaghnia [32].

2.4.3. Total Phenolic and Total Flavonoid

The Folin–Ciocalteu colorimetric method was used to determine the total phenolic content of Keitt mango tree leaves according to Singleton et al. [33] and expressed as (mg/g) using gallic acid as a standard. The aluminum chloride ($AlCl_3$) colorimetric method was used to determine the total flavonoid content in fresh leaves of Keitt mango cultivar according to Chang et al. [34], using as Rutin a standard and expressed as mg/g.

2.5. Tree Yield

Harvesting was achieved during the regular commercial harvesting time on 1st November in both seasons [3], and yield (Kg/tree) was recorded. The percentage was calculated by using the Abd El–Naby [35] Equation.

$$\text{Yield increasing (\%)} = \text{Yield (treatment)} - \text{Yield (control)} \times 100/\text{Yield (control)}.$$

For fruit sunburn percentage: At harvest time, sunburned fruits per tree were counted, and percentage of sunburned fruits per tree was calculated by using the Mohsen and Ibrahim [20] equation as follows:

$$\text{Sunburned fruits \%} = \text{No. of sunburned fruits/tree} \div \text{Total No. of fruits/tree} \times 100$$

2.6. Physical Characteristics of Fruits

At harvest, fruits were collected in a bag and then transferred to the chemical analytical laboratory of the department of horticulture, Faculty of Agriculture in Cairo, Al-Azhar University. Samples of five fruits of each tree were replicated three times and devoted to determining the following parameters: fruit volume (cm^3), fruit length (cm), fruit height (cm), fruit diameter (cm), peel weight (g), pulp weight (g) and seed weight (g).

2.7. Fruit Total Soluble Solids (TSS%) and Total Fruit Acidity Percentage

Fruit total soluble solids (TSS percentage) and total fruit acidity percentage fruit juice TSS% were measured using a digital refractometer (force-Gouge ModelIGV-O.SA to FGV-100A, Shimpo instruments). Total acidity was determined by titration and expressed as citric acid according to AOAC [36].

Total soluble solids/acid ratio was calculated from the values of total soluble solids divided by the values of total acids.

Ascorbic acid (vitamin C) expressed as (mg/100 mL juice) was estimated by titrating the juice sample with 2,6 dichlorophenol indophenol dye according to AOAC [36].

2.8. Statistical Analysis

All data obtained during both seasons were obtained using one-way ANOVA according to Snedecor [37] and CoStat software according to Stern [38].

3. Results and Discussion

3.1. Effect of Kaolin Spry on Vegetative Growth

Data in Figure 2A,B indicate that all kaolin treatments increased leaf area and tree canopy volume compared with the control of the studied Keitt mango cultivar in both seasons, particularly in 2020. Six percent of kaolin highly increased leaf area and tree canopy volume compared to that treated with 4% or 2% of kaolin. Regarding the 6% kaolin spray, leaf area was increased by 34.19% and 26.1% for the two studied seasons, respectively. Moreover, tree canopy volume was increased by 11.49% and 11.57% for both seasons. The kaolin application at 6% coincided with the cell expansion stage, which continued longer than the lower concentrations (4% or 2%). The findings are consistent with those of other researchers who discovered that spraying kaolin and kaolin clay at concentrations ranging from 25.5 to 75 g/L after fruit set increased leaf area and tree canopy volume [15,21,23,39–42]. The increase in vegetative growth parameters could be attributed to the effect of the foliar spray of kaolin on the leaf area, and canopy volume characteristics may be related to the direct impact of kaolin on tree resistance to abiotic stress, including drought [19,43]. Furthermore, kaolin foliar spray has been shown to improve CO_2 assimilation at high temperatures [19,43]. Such gains can explain the enhancement of plant growth and chlorophyll content that is associated with higher plant water content. It was determined that spraying kaolin at concentrations of 2%, 4%, or 6% following the fruit set phenological stage improved the vegetative growth parameters of the Keitt mango tree when compared to the control.

3.2. Effect of Kaolin on the Photosynthetic Pigments Leaf of Keitt cv.

Changes in the content of photosynthetic pigments, including chlorophyll a and b, total chlorophyll, carotenoids, and total pigments of Keitt mango trees during solar radiation with different concentrations of kaolin spray are illustrated in Figure 3A–D and 4D. Keitt mango leaves treated with foliar spray of different concentrations of kaolin caused a significant increase in photosynthetic pigments under solar radiation compared to the control. Maximum increases in chlorophyll a and b and carotenoids were obtained using 6% kaolin with values of 1.036, 0.577, and 0.359 mg/g fresh weight, respectively. As shown in Figure 3D, increasing the concentrations of kaolin from 0% to 6% led to an increase in the values of total chlorophyll and total pigments in the leaves of Keitt mango under solar radiation. High temperatures cause a decrease in the chlorophyll content through

their indirect effect of inhibiting the activity of the RuBisCO enzyme at temperatures higher than 35 °C [44,45]. Spraying mango trees with kaolin led to intense light reflection and a decrease in solar radiation stress on the leaves and a decrease in temperature of more than one degree, which subsequently led to the enhancement of the photosynthesis process and an increase in the content of leaf chlorophyll [46,47]. Dinis et al. [48] found that the application of kaolin spray led to an increase in photochemical reflectance and photosynthetic pigments in a grapevine plant. These results are consistent with Abdallah et al., 2019, and Khavari et al., 2021 [49,50].

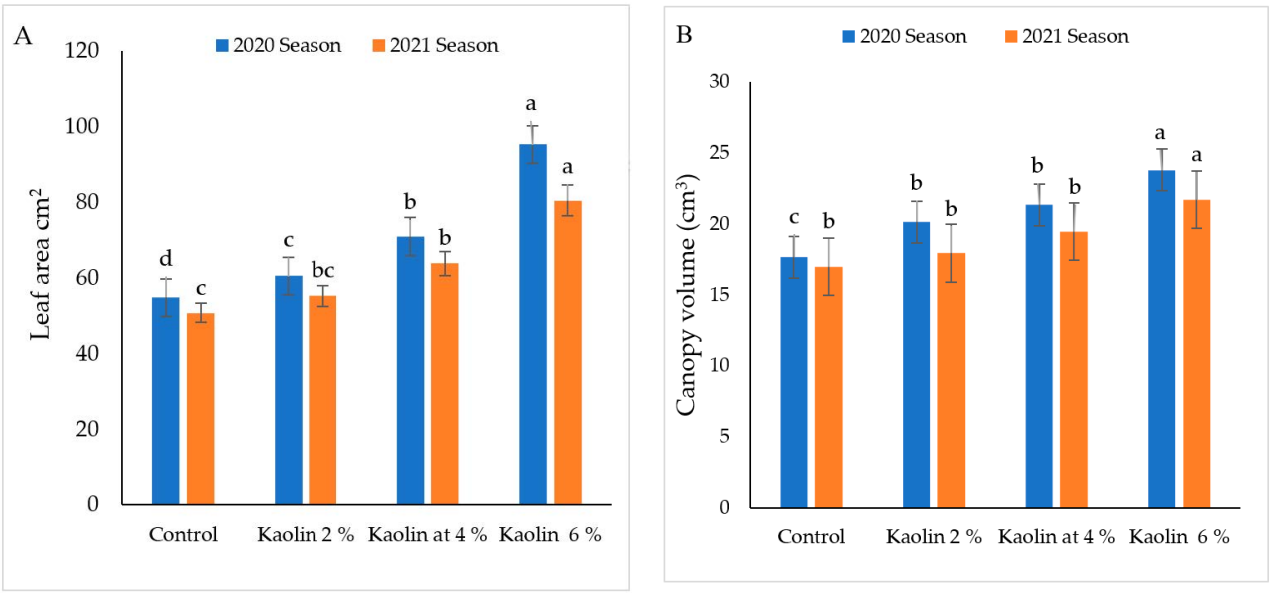


Figure 2. Effect of kaolin spray on: (**A**) leaf area (cm^2) and (**B**) canopy volume (cm^3) of Keitt mango cultivar during seasons 2020 and 2021. Bars indicate mean values ± SE (n = 9). Different letters above columns indicate significant differences among pruning treatments at $p = 0.05$ according to Bartlett's test.

3.3. Effect of Kaolin on the Antioxidant Activity of Leaf

Results in Figure 4A–C show the influence of the foliar application of different concentrations of kaolin on enzyme activities in the leaves of the Keitt mango cultivar under solar radiation. The highest increase in enzyme activity was recorded in control plants, whereas the lowest activity of the enzymes was when spraying the leaves at 6% kaolin. CAT, POX, and PPO activities were decreased by 57.27%, 45.62%, and 55%, respectively, when spraying mango leaves with 6% kaolin as compared to the control (Figure 4).

Under various stresses, such as drought and heat stress, especially during the summer, the production of reactive oxygen species (ROS) increases, which causes the breakdown of proteins and cell membranes, and reduces photosynthesis and plant growth [49]. Therefore, plants have developed defense mechanisms to remove the harmful effects of ROS, including enzymatic and non-enzymatic antioxidants [51].

Catalase and peroxidase convert H_2O_2 to oxygen and water, which are harmless molecules for plants [52]. Under high temperatures, the activity of catalase, peroxidase, and polyphenol oxidase enzymes increases to bring about a balance between ROS and antioxidant enzymes [51,52]. This balance varies according to the type of stress, duration of exposure to stress, plant species, and growth stage [53]. Our results showed that all treatments with kaolin reduced the enzyme activities (Figure 4A–C). This indicates that under kaolin treatments, mango trees are more stable and produce less reactive oxygen species (ROS), which reduces the need to increase these enzymes. These results were in harmony with the results obtained by [54].

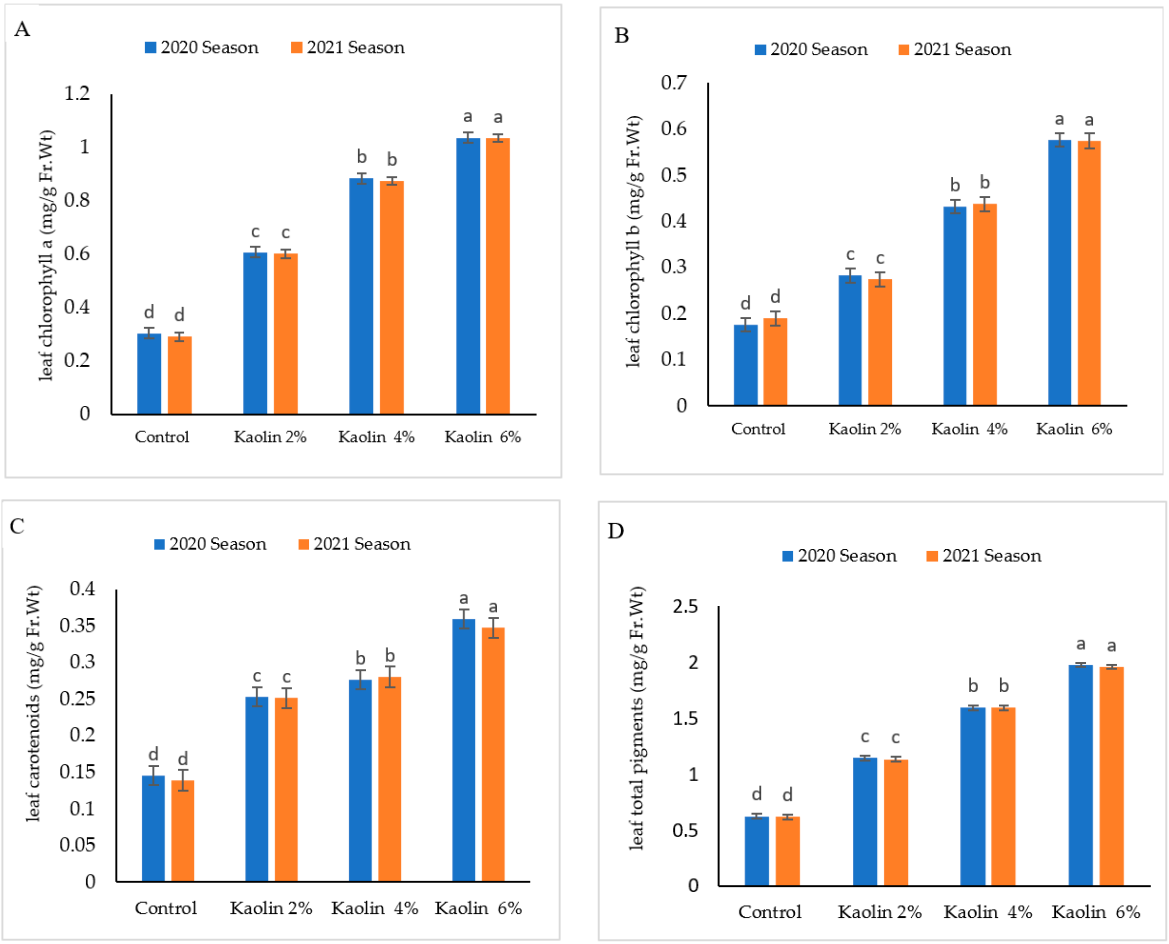


Figure 3. Effect of kaolin spray on: (**A**) leaf chlorophyll a (mg/g Fr.Wt), (**B**) leaf chlorophyll b (mg/g Fr.Wt), (**C**) leaf carotenoids (mg/g Fr.Wt) and (**D**) leaf total pigments (mg/g F.W) of Keitt mango cultivar during the seasons 2020 and 2021. Bars indicate mean values ± SE (n = 9). Different letters above columns indicate significant differences among pruning treatments at $p = 0.05$ according to Bartlett's test.

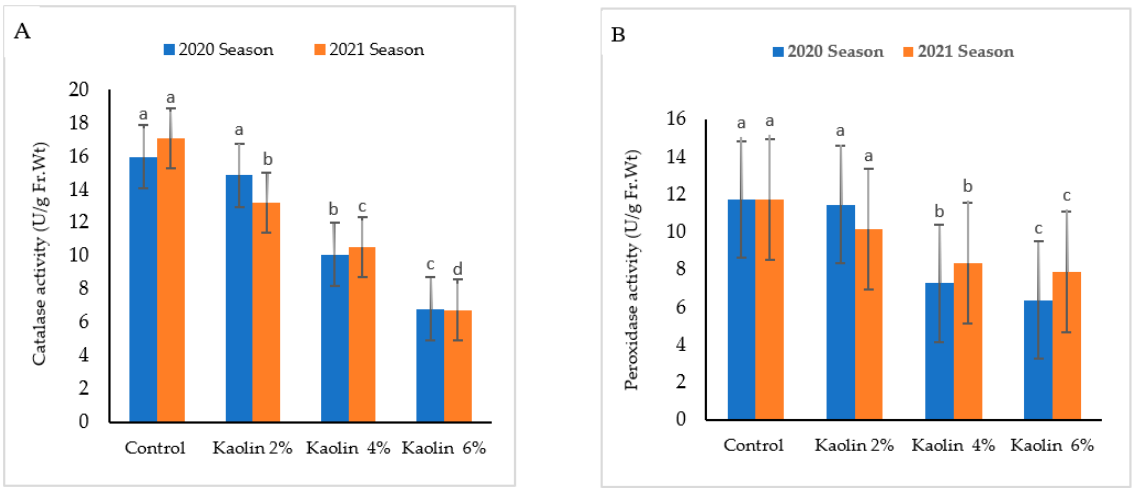


Figure 4. *Cont.*

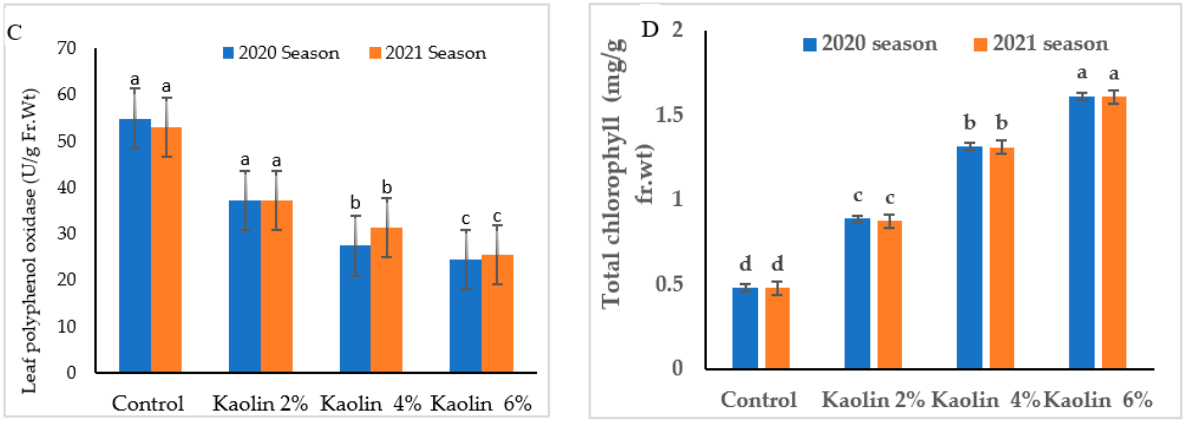


Figure 4. Effect of kaolin spray on: (**A**) leaf catalase activity (U/g Fr.Wt), (**B**) leaf peroxidase activity (U/g Fr.Wt), (**C**), leaf polyphenol oxidase (U/g Fr.Wt) and (**D**) total chlorophyll (mg/g Fr.Wt.) of Keitt mango cultivar during the seasons 2020 and 2021. Bars indicate mean values ± SE (n =9). Different letters above columns indicate significant differences among pruning treatments at $p = 0.05$ according to Bartlett's test.

3.4. Effect of Kaolin on Total Phenolic and Total Flavonoid of Keitt cv. Leaf

Data showed that the total phenolic content in the leaves of Keitt mango trees significantly increased by 3.86% with 2% kaolin sprayed compared to the control. Moreover, the concentration of total phenolic decreased by 13.78% and 25% between the control and 4% and 6% kaolin-sprayed leaves, respectively (Figure 5A). The total amount of flavonoids in mango leaves was not significantly different between controls until 4% kaolin, but the concentrations of total flavonoids significantly decreased by 35.7% when spraying mango leaves with 6% kaolin (Figure 5B). The increase in antioxidants, such as total phenolics and flavonoids under high temperatures is one of the defense mechanisms used by plants against oxidative stress [55]. Under high temperatures (control), phenylalanine ammonia-lyase activates [56], leading to an increase in total phenolic, while under normal conditions, phenylalanine is used to synthesize proteins [57], and this explains the decrease in total phenolic when spraying mango leaves with 4% and 6% kaolin (Figure 5). These results are consistent with [48,58,59].

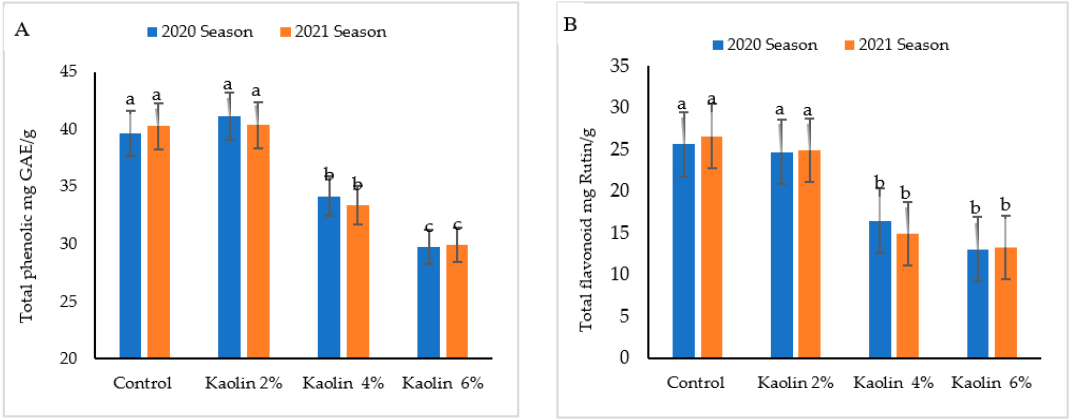


Figure 5. Effect of kaolin spray on: (**A**) leaf total phenolic (mg GAE/g) and (**B**) leaf total flavonoid (mg Rutin/g) of Keitt mango cultivar during the seasons 2020 and 2021. Bars indicate mean values ± SE (n = 9). Different letters above columns indicate significant differences among pruning treatments at $p = 0.05$ according to Bartlett's test.

3.5. Effect of Kaolin on Yield (kg/Tree)

The results in Figure 6A,B clearly show that foliar spray of 2%, 4%, or 6% of kaolin to Keitt mango trees significantly increased both fruit yield (kg/tree) and the percentage

increase in yield/tree in comparison to those of the control in the two studied seasons. Mango trees sprayed with 6% kaolin induced the maximum yield per tree, followed in descending order by 4%, 2%, and finally by the last control of kaolin, which possessed the lowest values. The present results are in agreement with that previously obtained by Baiea et al. [3], who found that kaolin foliar spray at concentrations of 25.5 g and 75 g/L reduced fruit sunburn damage and improved the yield and fruit quality of Keitt mango fruits. Furthermore, Hagagg et al. [19] reported that spraying kaolin and calcium carbonate at a concentration of 7% improved the yield per tree of Kalamata and Manzanillo olive cultivars. Similarly, Mohsen and Ibrahim [20] found that kaolin treatment reduced both the fruit's sunburn and the blotching of Murcott tangerines in comparison to untreated trees. The higher kaolin concentration (6%) significantly increased yield per tree more than other treatments or the control. This was true in the two studied seasons compared with the control. A clear trend for the effect of kaolin application on yield could be identified. Consequently, higher kaolin concentrations significantly increased yield more than lower concentrations or the control in two successive seasons. In 2020, kaolin-sprayed trees at a concentration of 6% produced a higher raise (184%) in mango yield than other treatments or the control. In the second season of the study, kaolin presented a similar trend (Figure 6C). The present result is confirmed by the previous work by Brito et al. [58], who found that kaolin treatment increased the yield of the olive cv."Cobrançosa". The increase caused by kaolin in yield/tree could be attributed to the action of kaolin in reducing the tree canopy temperature and abiotic stress [58]. In comparison to the control, reduced stress results in enhanced fruit size and yield [3,60,61].

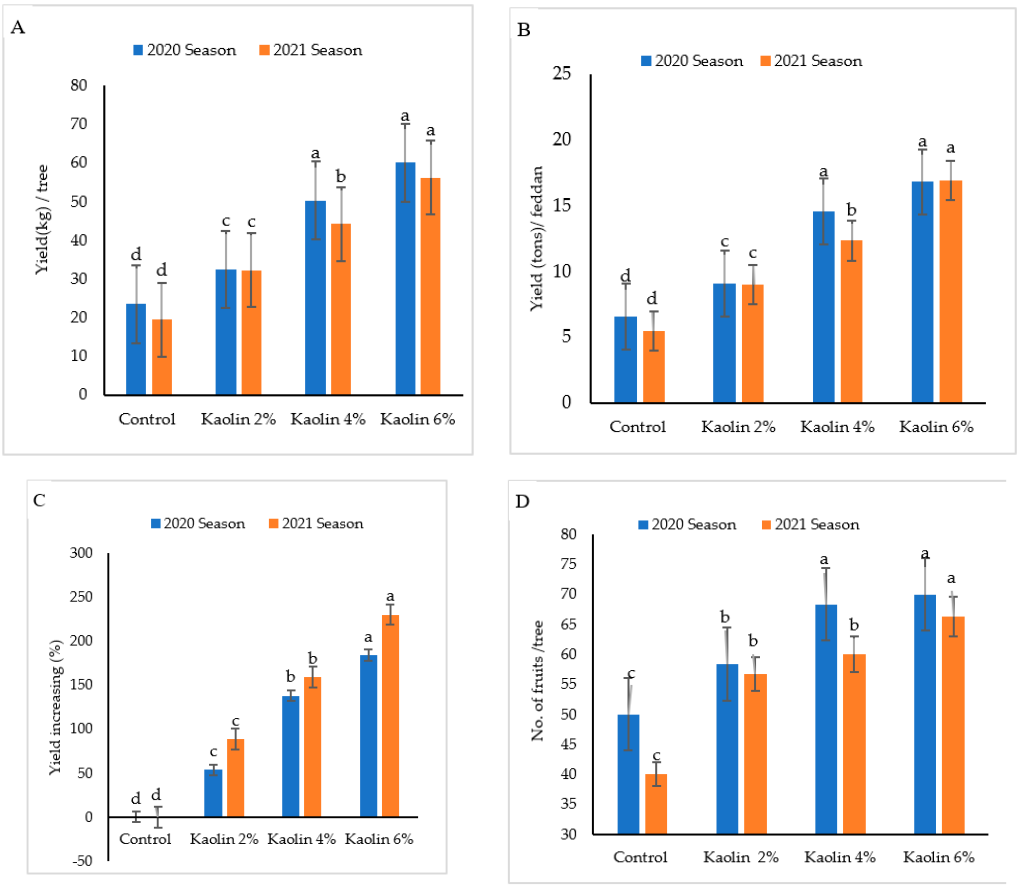


Figure 6. Effect of kaolin spray on: (**A**) tree yield (Kg/tree), (**B**) tree yield (tons/feddan), (**C**) tree yield increasing (%) and (**D**) No. of fruits per tree of Keitt mango cultivar during the seasons 2020 and 2021. Bars indicate mean values ± SE (n = 9). Different letters above columns indicate significant differences among pruning treatments at $p = 0.05$ according to Bartlett's test.

3.6. Effect of Kaolin on Fruit Physical Characteristics at Harvest

Figures 7 and 8 clearly show that kaolin spray applied on the foliage of the Keitt mango cultivar in summer with concentrations of 2%, 4%, or 6% increased the number of fruits, fruit weight, and fruit dimensions (diameter, height, length, and volume), as well as pulp and seed weights (in grams) in comparison to that of the control in both seasons. A higher concentration of kaolin spray at 6% resulted in more of an increase in the number of fruits per tree and the fruit weight of Keitt and to a lesser extent than other treatments or control. The rise in fruit numbers and weight could be attributed to the role of kaolin in reducing abiotic stress. The present results are in agreement with that previously obtained by Zaky [12], who found that kaolin foliar spray at concentrations of 3% or 6% increased the fruit weight and volume of 'Balady' mandarin trees. Furthermore, Mohsen and Ibrahim [20] discussed that kaolin treatment at 4% increased both the number of fruits per tree and the fruit weight of Murcott tangerines in comparison to untreated trees. Similarly, Gullo et al. [23] found that kaolin spray increased fruit numbers per tree and fruit volume of sweet oranges when compared with untreated trees. The reduction in abiotic stress results in increased fruit weight and numbers when compared with untreated trees [3,61]. We can conclude that foliar kaolin spray applied on June 15th, July 15th, and August 15th of the mango cultivar increased fruit weight, fruit volume, pulp weight, and seed weight when compared with those of the control. Six percent of kaolin spray induced more of an increase in the physical parameters of fruits than the lower concentrations.

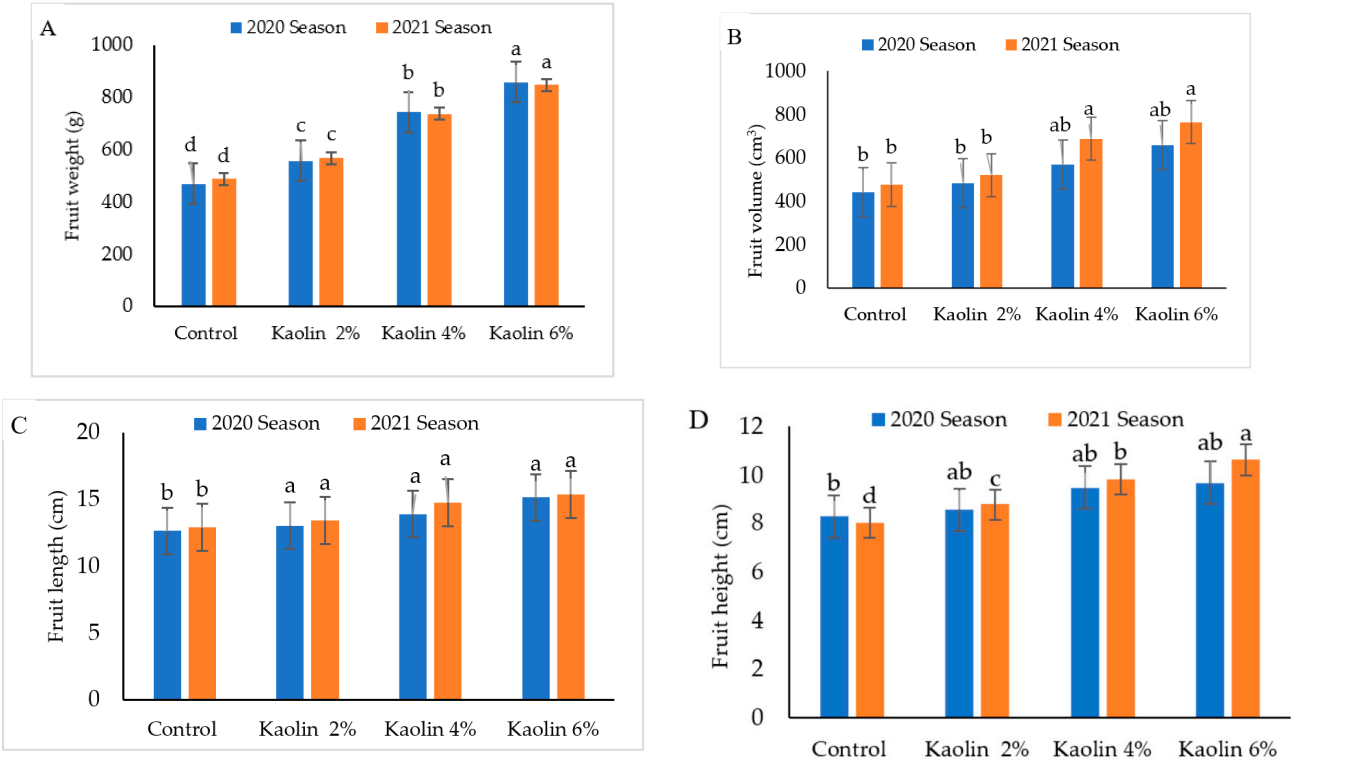


Figure 7. Effect of kaolin spray on: (**A**) fruit weight (g), (**B**) fruit volume (cm^3), (**C**) fruit length (cm) and (**D**) fruit height (cm) of Keitt mango cultivar during the seasons 2020 and 2021. Bars indicate mean values ± SE (n = 9). Different letters above columns indicate significant differences among pruning treatments at $p = 0.05$ according to Bartlett's test.

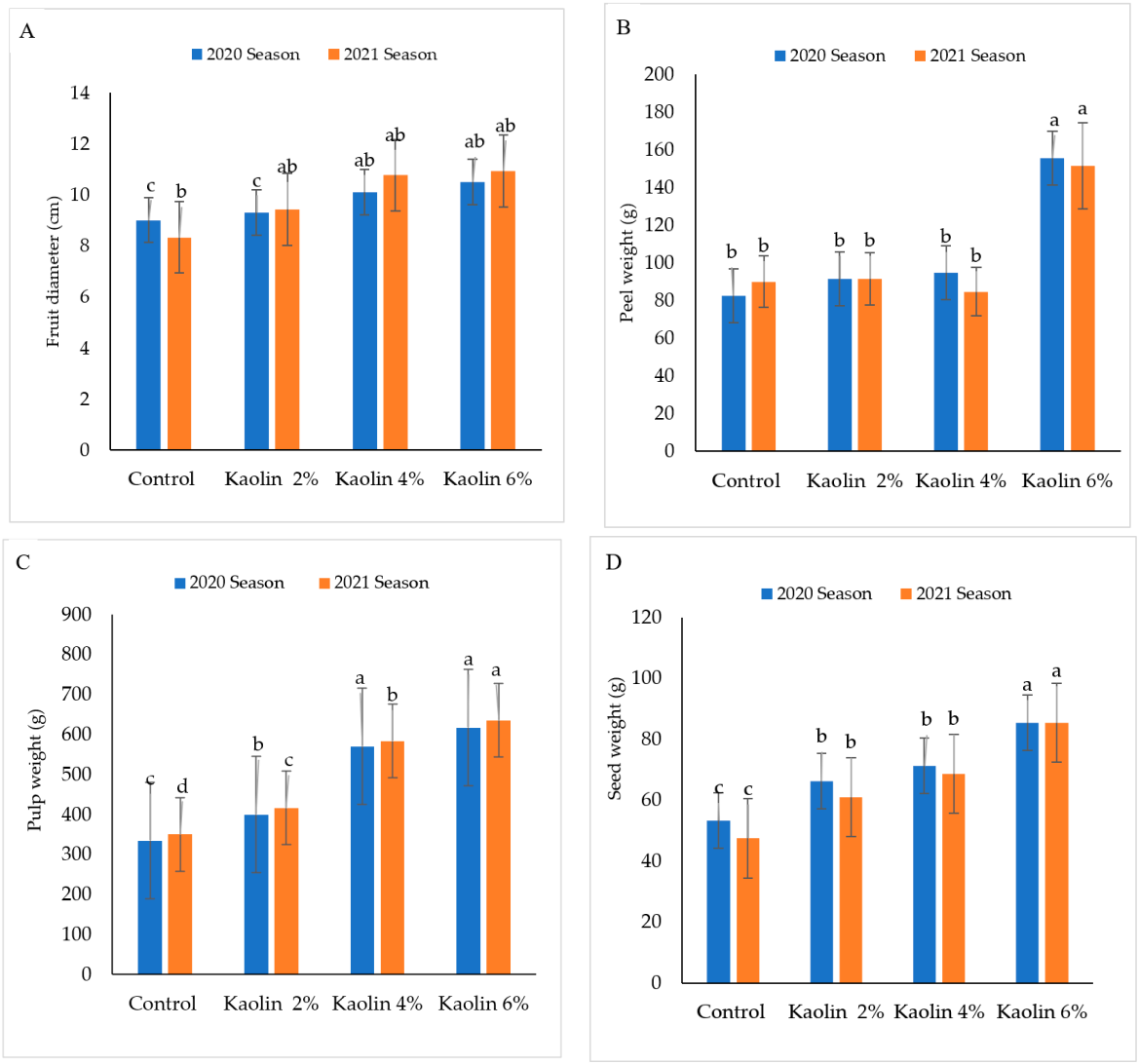


Figure 8. Effect of kaolin spray on: (**A**) fruit diameter (cm), (**B**) peel weight (cm), (**C**) pulp weight (g) and (**D**) seed weight (g) of Keitt mango cultivar during the seasons 2020 and 2021. Bars indicate mean values ± SE (n = 9). Different letters above columns indicate significant differences among pruning treatments at $p = 0.05$ according to Bartlett's test.

3.7. Effect of Kaolin Spray on Sunburned Fruits% of Keitt Mango at Harvest

Data in Figure 9 clearly shows that kaolin applied to the foliage of the Keitt mango cultivar in concentrations of 2%, 4%, or 6% decreased the percentage of sunburned fruit compared to that of the control in both the 2020 and 2021 seasons. A higher concentration of kaolin at 6% resulted in a greater decrease in the percentage of sunburned fruit of the Keitt cultivar than 2% and 4% or the control (Figure 10). With respect to 6% kaolin spray, sunburned fruit percentage was decreased by 77.6% and 76.3% for both seasons, respectively. The current findings are consistent with those obtained previously by Mohsen and Ibrahim, 2021 (21) and Lombardini et al., 2005 [20], who proposed that kaolin treatment reduced both sunburned fruit and blotching of Murcott tangerine trees in comparison to untreated trees. The decrease in sunburned fruit percentage could be attributed to the role of kaolin in the protection of fruit trees against abiotic stress. The first is a visible particle film that reflects harmful UV and IR light. The second is a naturally occurring compound found in all fruit trees that triggers the innate stress response mechanism [12]. Moreover, the increase in leaf area and canopy volume caused by kaolin and the subsequent stimulation of photosynthesis intensity contributed to the decrease in the sunburned fruit (Figure 9).

The present results are in full agreement with those previously obtained by [3,60,61], who found that kaolin application decreased the percentage of sunburned fruits in fruit tree cultivars.

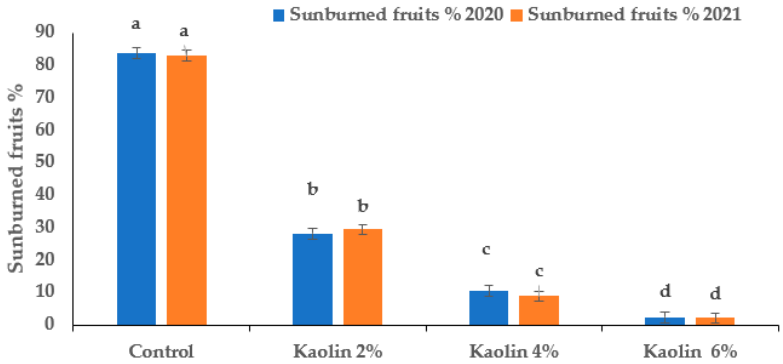


Figure 9. Effect of kaolin spray on sunburned fruits % of Keitt mango cultivar during the seasons 2020 and 2021. Bars indicate mean values ± SE (n = 9). Different letters above columns indicate significant differences among pruning treatments at $p = 0.05$ according to Bartlett's test.



Figure 10. (**A**) Sunburned fruits disorder arrowed (control) and (**B**) Keitt mango tree fruits after kaolin foliar spray in June.

3.8. Effect of Kaolin Spray on Fruit Chemical Characteristics at Harvest

According to the data in Figure 11A,C, the percentage of total soluble solids of mango fruit juice at harvest, TSS/acid ratio, and vitamin C were significantly increased in all kaolin-treated trees compared to the control in both seasons. Higher concentration (6%) induced a greater increase in TSS% and TSS/acid ratio than 2%, 4%, or the control. These results agree with Baiea et al. [3], who found that kaolin foliar spray at concentrations of 25.5 and 75 g/L increased the TSS% of Keitt mango fruits in comparison to the control. The increase in the TSS% of fruit at harvest might be due to the intensive photosynthesis in trees previously treated with kaolin, which leads to an increase in manufactured carbohydrates for the benefit of the fruit. It is remarkable that mango trees that were previously treated with kaolin showed a significant increase in the number of fruits per tree more than the control (Figure 6D), with a simultaneous increase in the TSS % of fruits at harvest.

Regarding the total acidity of fruit juice, results in Figure 11B show the opposite trend of that TSS percentage in all kaolin treatments compared to the control in the two studied seasons. The kaolin treatment resulted in a decrease in total fruit acidity compared with that of the control (Figure 11B). The significant decrease in total fruit acidity as a result of a previous application with kaolin could be due to the promotion that occurred in fruit maturity, where the fruit ripened earlier than those that were untreated; however, the fruits were all harvested on the same date. According to Baiea et al. [3], the fruit quality of Keitt mangoes was improved after spraying the trees with kaolin at 25.5 or 75 g/L, as the fruit TSS% and TSS/acid ratio were increased, while total fruit acidity was decreased in

comparison to those of the control. Similarly, Gullo et al. [23] reported that spraying kaolin at a concentration of 50 g/L improved the fruit quality parameters of the Navelina ISA sweet orange cultivar.

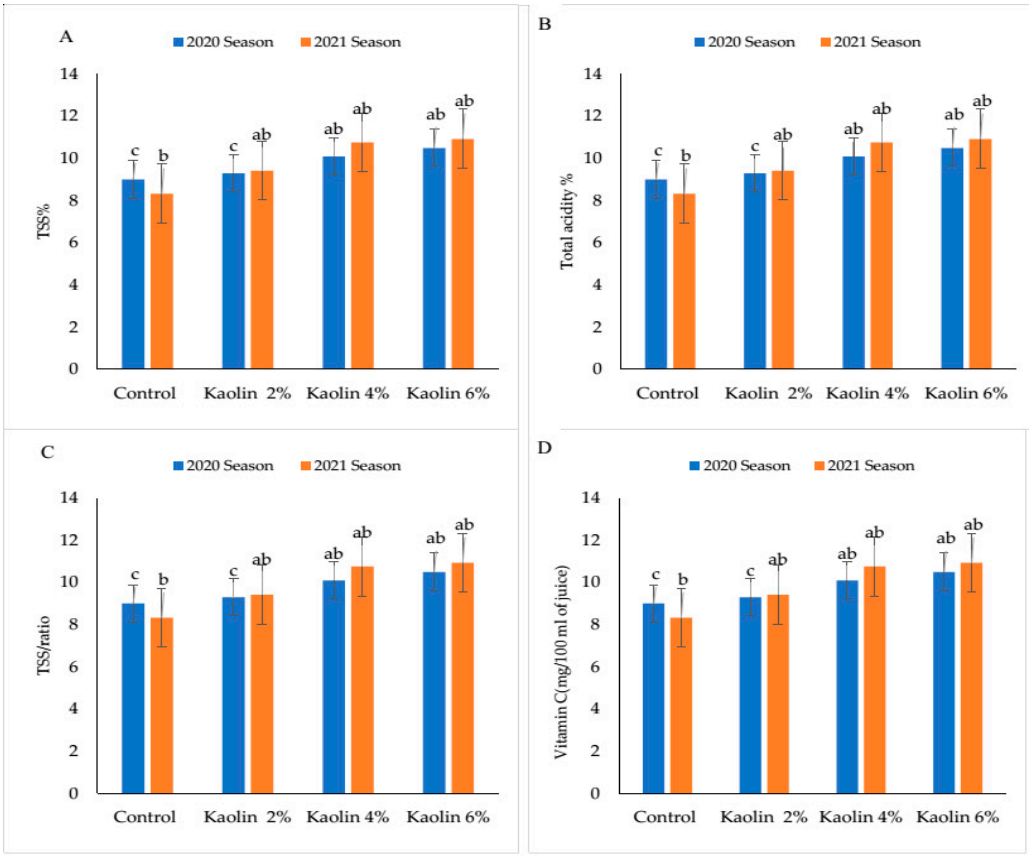


Figure 11. Effect of kaolin spray on: (**A**) TSS (%), (**B**) total acidity (%), (**C**) TSS/acid ratio and (**D**) vitamin C (mg/100 mL of juice) of Keitt mango cultivar during the seasons 2020 and 2021. Bars indicate mean values ± SE (n = 9). Different letters above columns indicate significant differences among pruning treatments at $p = 0.05$ according to Bartlett's test.

4. Conclusions

This work provided evidence that leaf area, canopy volume, photosynthesis pigments such as chlorophyll a and b, carotenoids, yield, and fruit physical and chemical characteristics of mango are affected by applied kaolin treatments during the summer months. Kaolin led to an increase in mango yield and a decrease in leaf content of antioxidants such as total phenolic, total flavonoid, CAT, POX, and PPO enzyme activity percentage and sunburned fruits. A 6% concentration of kaolin spray induced more increases in the mentioned parameters of fruits, such as yield and fruit quality as well as vegetative growth, than the lower concentrations. The kaolin compound was effective in reducing the degree of abiotic stress and in mitigating the adverse summer conditions typical of subtropical mango growing areas.

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visualization, A.E.H., H.F.A.-A., H.E.-k., S.S., M.S.M.A., A.A.E.-Y., M.M.T. and A.E.; supervision, A.E.; project administration, A.E.H. and A.E.; funding acquisition, A.E.H., N.I.A., S.S., M.S.M.A., K.A. and A.E. All authors have read and agreed to the published version of the manuscript.

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References

1. Karar, H.; Bakhsh, M.; Abbas, G.; Hameed, A. Studies on Biology and Antibiosis Resistance in Mango (*Mangiferae indica*) Varieties against Mango Mealy Bug, *Drosicha mangiferae* Green (Hemiptera: Margarodidae). *Cercet. Agron. Mold.* **2018**, *51*, 101–110. [CrossRef]
2. Ribeiro, S.M.R.; De Queiroz, J.H.; De Queiroz, M.E.L.R.; Campos, F.M.; Sant'Ana, H.M.P. Antioxidant in Mango (*Mangifera indica* L.) Pulp. *Mater. Veg.* **2007**, *62*, 13–17. [CrossRef] [PubMed]
3. Baiea, M.H.M.; El-Gioushy, S.F.; El-Badawy, H.E.M. Efficacy of Kaolin and Screen Duo Spraying on Fruit Sunburn, Yield and Fruit Quality of Keitt Mango Fruits. *J. Plant Prod.* **2018**, *9*, 1013–1020. [CrossRef]
4. Guirado, E.; Farré, J.; Hermoso, J. Mango Cultivar Studies in Southern Mainland Spain. *Acta Hortic.* **2009**, *820*, 127–132. [CrossRef]
5. Rodriguez, J.; Anoruo, A.; Jifon, J.; Simpson, C. Physiological Effects of Exogenously Applied Reflectants and Anti-Transpirants on Leaf Temperature and Fruit Sunburn in Citrus. *Plants* **2019**, *8*, 549. [CrossRef]
6. Mishra, D.; Tripathi, A.; Nimbolkar, P. Review on Physiological Disorders of Tropical and Subtropical Fruits: Causes and Management Approach. *Int. J. Agric. Environ. Biotechnol.* **2016**, *9*, 925. [CrossRef]
7. Schrader, L.; Sun, J.; Zhang, J.; Felicetti, D.; Tian, J. Heat and Light-Induced Apple Skin Disorders: Causes and prevention. *Acta Hortic.* **2008**, *772*, 51–58. [CrossRef]
8. Tsai, M.-S.; Lee, T.-C.; Chang, P.-T. Comparison of Paper Bags, Calcium Carbonate, and Shade Nets for Sunscald Protection in 'Murcott' Tangor Fruit. *HortTechnology* **2013**, *23*, 659–667. [CrossRef]
9. Sarooghinia, F.; Khadivi, A.; Abbasifar, A.; Khaleghi, A. Foliar Application of Kaolin to Reduce Sunburn in 'Red Delicious' Apple. *Erwerbs-Obstbau* **2019**, *62*, 83–87. [CrossRef]
10. Lal, N.; Sahu, N. Management Strategies of Sun Burn in Fruit Crops-A Review. *Int. J. Curr. Microbiol. Appl. Sci.* **2017**, *6*, 1126–1138. [CrossRef]
11. Brito, C.; Dinis, L.-T.; Moutinho-Pereira, J.; Correia, C. Kaolin, an emerging tool to alleviate the effects of abiotic stresses on crop performance. *Sci. Hortic.* **2019**, *250*, 310–316. [CrossRef]
12. Zaky, M.A. Impact of spraying some chemical substances on controlling sunburn of Balady mandarin fruits. *Egypt. J. Hortic.* **2018**, *45*, 229–236. [CrossRef]
13. Gharaghani, A.; Javarzari, A.M.; Vahdati, K. Kaolin particle film alleviates adverse effects of light and heat stresses and improves nut and kernel quality in Persian walnut. *Sci. Hortic.* **2018**, *239*, 35–40. [CrossRef]
14. Gindaba, J.; Wand, S. Comparison of climate ameliorating measures to control sunburn on 'fuji' apples. *Acta Hortic.* **2008**, *772*, 59–64. [CrossRef]
15. Kerns, D.L.; Wright, G.C. Protective and Yield Enhancement Qualities of Kaolin on Lemons. In *Citrus and Deciduous Fruit and Nut Research Report*; College of Agriculture, University of Arizona: Tucson, AZ, USA, 2000.
16. Colavita, G.; Blackhall, V.; Valdez, S. Effect of kaolin particle films on the temperature and solar injury of pear fruits. *Acta Hortic.* **2011**, *909*, 609–615. [CrossRef]
17. Khalifa, S.A.M.; Shedid, E.S.; Saied, E.M.; Jassbi, A.R.; Jamebozorgi, F.H.; Rateb, M.E.; Du, M.; Abdel-Daim, M.M.; Kai, G.-Y.; Al-Hammady, M.A.M.; et al. Cyanobacteria—From the Oceans to the Potential Biotechnological and Biomedical Applications. *Mar. Drugs* **2021**, *19*, 241. [CrossRef]
18. Ennab, H.; El-Sayed, S.; El-Enin, M.A. Effect of kaolin applications on fruit sunburn, yield and fruit quality of Balady mandarin (*Citrus reticulata*, Blanco). *Menoufia J. Plant Prod.* **2017**, *2*, 129–138. [CrossRef]
19. Hagagg, L.F.; Maklad, M.F.; Raslan, M.A. Effect of Kaolin and Calcium Carbonate on Vegetative Growth, Leaf Pig-ments and Mineral Content of Kalamata and Manzanillo Olive Trees. *Middle East J. Agric.* **2019**, *8*, 298–310.
20. Mohsen, F.S.; Ibrahim, M.M. Reducing fruit sunburn and splitting in Murrcot tangarine fruits by using Silicate application. *Arab Univ. J. Agric. Sci.* **2021**, *29*, 437–445. [CrossRef]
21. Lombardini, L.; Harris, M.K.; Glenn, D.M. Effects of Particle Film Application on Leaf Gas Exchange, Water Relations, Nut Yield, and Insect Populations in Mature Pecan Trees. *HortScience* **2005**, *40*, 1376–1380. [CrossRef]

22. Saied, E.M.; El-Maradny, Y.A.; Osman, A.A.; Darwish, A.M.G.; Abo Nahas, H.H.; Niedbała, G.; Piekutowska, M.; Abdel-Rahman, M.A.; Balbool, B.A.; Abdel-Azeem, A.M. A Comprehensive Review about the Molecular Structure of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2): Insights into Natural Products against COVID-19. *Pharmaceutics* **2021**, *13*, 1759. [CrossRef] [PubMed]
23. Gullo, G.; Dattola, A.; Vonella, V.; Zappia, R. Effects of two reflective materials on gas exchange, yield, and fruit quality of sweet orange tree *Citrus sinensis* (L.) Osb. *Eur. J. Agron.* **2020**, *118*, 126071. [CrossRef]
24. Ali, M.; Anwar, R.; Yousef, A.; Li, B.; Luvisi, A.; Bellis, L.; Aprile, A.; Chen, F. Influence of Bagging on the Development and Quality of Fruits. *Plants* **2021**, *10*, 358. [CrossRef] [PubMed]
25. Black, J.L.; Evans, C.A.; Ensminger, O.D.; White, L.E.; Clark, F.E.; Dinaver, R.C. *Methods of Soil Analysis Part II, Chemical and Microbiological Properties*; American Society of Agronomy: Madison, WI, USA, 1982.
26. Zekri, M. Original article Citrus rootstocks affect scion nutrition, fruit quality, growth, yield and economical return. *Fruits* **2000**, *55*, 231–239.
27. Ahmed, A.; Morsy, M.H. A new method for measuring leaf area in different fruit species. *Minia J. Agric. Res. Dev. (Egypt)* **2006**, *19*, 97–105.
28. Brito, G.G.; Sofiatti, V.; Brandão, Z.N.; Silva, V.; Silva, F.M.; Silva, D.A. Non-destructive analysis of photosynthetic pigments in cotton plants. *Acta Sci. Agron.* **2011**, *33*, 671–678. [CrossRef]
29. Esfandiari, E.; Sabaghnia, N. The effect of Fe-deficiency on antioxidant enzymes' activity and lipid peroxidation in wheat leaves. *Agron. Sci.* **2012**, *67*, 25–34. [CrossRef]
30. Aebi, H. [13] Catalase in vitro. *Methods Enzymol.* **1984**, *105*, 121–126.
31. Amako, K.; Chen, G.-X.; Asada, K. Separate Assays Specific for Ascorbate Peroxidase and Guaiacol Peroxidase and for the Chloroplastic and Cytosolic Isozymes of Ascorbate Peroxidase in Plants. *Plant Cell Physiol.* **1994**, *35*, 497–504. [CrossRef]
32. Kavrayan, D.; Aydemir, T. Partial purification and characterization of polyphenoloxidase from peppermint (*Mentha piperita*). *Food Chem.* **2001**, *74*, 147–154. [CrossRef]
33. Singleton, R.M.; Orthofer, L.V.; Lamuela-Raventos, R. Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. *Methods Enzymol.* **1999**, *299*, 152–178. Available online: https://www.sciencedirect.com/science/article/abs/pii/S0076687999990171 (accessed on 1 January 2020).
34. Chang, C.-C.; Yang, M.-H.; Wen, H.-M.; Chern, J.-C. Estimation of total flavonoid content in propolis by two complementary colometric methods. *J. Food Drug Anal.* **2002**, *10*, 3. [CrossRef]
35. Abd El-Naby, S.K.M.; Mohamed, A.A.A.; El-Naggar, Y.I.M. Effect of melatonin, GA3 and NAA on vegetative growth, yield and quality of 'canino' apricot fruits. *Acta Sci. Pol. Hortorum Cultus* **2019**, *18*, 167–174. [CrossRef]
36. AOAC Association of Official Analytical Chemist. *Official Methods of Analysis*, 18th ed.; AOAC: Gaithersburg, MD, USA, 2016.
37. Snedecor. *Statistical Methods*, 7th ed.; Iowa State University Press: Ames, IA, USA, 1990.
38. Stern, R. Review of 'Co-Stat-Statistical Software. *Exp. Agric.* **1991**, *27*, 87. [CrossRef]
39. Saour, H.; Makee, G. Effects of kaolin particle film on olive fruit yield, oil content and quality. *Adv. Hortic. Sci.* **2003**, *17*, 204–206.
40. Bedrech, F.G. Usage of some sunscreens to protect the Thompson Seedless and Crimson Seedless grapevines growing in hot climates from sunburn. *Nat. Sci.* **2015**, *13*, 35–41. [CrossRef]
41. El-Said, E.M. Effect of irrigation intervals and some antitranspirants on growth, yield and fruit quality of eggplant. *J. Plant Prod.* **2015**, *6*, 2079–2091. [CrossRef]
42. Mahian, R.A.; Hakimzadeh, V. Sugar alcohols: A review. *Int. J. PharmTech Res.* **2016**, *9*, 407–413.
43. Glenn, D.M.; Prado, E.; Erez, A.; McFerson, J.; Puterka, G.J. A Reflective, Processed-Kaolin Particle Film Affects Fruit Temperature, Radiation Reflection, and Solar Injury in Apple. *J. Am. Soc. Hortic. Sci.* **2002**, *127*, 188–193. [CrossRef]
44. Id, G.; Vs, J.; Vd, P.; Sb, G. Effect of different levels of pruning on quality of pomegranate (*Punica granatum* L.) cv. super Bhagwa. *Int. J. Chem. Stud.* **2019**, *7*, 2899–2902.
45. Demirevska-Kepova, K.; Holzer, R.; Simova-Stoilova, L.; Feller, U. Heat stress effects on ribulose-1,5-bisphosphate carboxylase/oxygenase, Rubisco binding protein and Rubisco activase in wheat leaves. *Biol. Plant* **2005**, *49*, 521–525. [CrossRef]
46. Rosati, A. Physiological Effects of Kaolin Particle Film Technology: A Review. *Funct. Plant Sci. Biotechnol. (Glob. Sci. Book)* **2007**, *1*, 100–105.
47. Núñez-López, D.C.; Ramírez-Godoy, A.; Restrepo-Díaz, H. Impact of Kaolin Particle Film and Synthetic Insecticide Applications on Whitefly Populations *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae) and Physiological Attributes in Bean (*Phaseolus vulgaris*) Crop. *HortScience* **2015**, *50*, 1503–1508. [CrossRef]
48. Dinis, L.T.; Malheiro, A.; Luzio, A.; Fraga, H.; Ferreira, H.; Gonçalves, I.; Pinto, G.; Correia, C.; Moutinho-Pereira, J. Improvement of grapevine physiology and yield under summer stress by kaolin-foliar application: Water relations, photosynthesis and oxidative damage. *Photosynthetica* **2018**, *56*, 641–651. [CrossRef]
49. Abdallah, M.M.S.; El-Bassiouny, H.M.S.; Abouseeda, M.A. Potential role of kaolin or potassium sulfate as anti-transpirant on improving physiological, biochemical aspects and yield of wheat plants under different watering regimes. *Bull. Natl. Res. Cent.* **2019**, *43*, 1–12. [CrossRef]
50. Khavari, M.; Fatahi, R.; Zamani, Z. Salicylic acid and kaolin effects on pomological, physiological, and phytochemical characters of hazelnut (*Corylus avellana*) at warm summer condition. *Sci. Rep.* **2021**, *11*, 4568. [CrossRef]
51. You, J.; Chan, Z. ROS Regulation During Abiotic Stress Responses in Crop Plants. *Front. Plant Sci.* **2015**, *6*, 1092. [CrossRef]

52. Møller, I.M.; Jensen, P.E.; Hansson, A. Oxidative Modifications to Cellular Components in Plants. *Annu. Rev. Plant Biol.* **2007**, *58*, 459–481. [CrossRef]
53. Abedi, T.; Pakniyat, H. Antioxidant enzymes changes in response to drought stress in ten cultivars of oilseed rape (*Brassica napus* L.). *Czech J. Genet. Plant Breed.* **2010**, *46*, 27–34. [CrossRef]
54. Cabo, S.; Morais, M.C.; Aires, A.; Carvalho, R.; Pascual-Seva, N.; Silva, A.P.; Gonçalves, B. Kaolin and seaweed-based extracts can be used as middle and long-term strategy to mitigate negative effects of climate change in physiological performance of hazelnut tree. *J. Agron. Crop Sci.* **2019**, *206*, 28–42. [CrossRef]
55. Bacelar, E.A.; Santos, D.; Moutinho-Pereira, J.; Gonçalves, B.; Ferreira, H.M.F.; Correia, C.M. Immediate responses and adaptative strategies of three olive cultivars under contrasting water availability regimes: Changes on structure and chemical composition of foliage and oxidative damage. *Plant Sci.* **2006**, *170*, 596–605. [CrossRef]
56. Wen, P.-F.; Chen, J.-Y.; Wan, S.-B.; Kong, W.-F.; Zhang, P.; Wang, W.; Zhan, J.-C.; Pan, Q.-H.; Huang, W.-D. Salicylic acid activates phenylalanine ammonia-lyase in grape berry in response to high temperature stress. *Plant Growth Regul.* **2008**, *55*, 1–10. [CrossRef]
57. Koricheva, J.; Larsson, S.; Haukioja, E.; Keinänen, M. Regulation of Woody Plant Secondary Metabolism by Resource Availability: Hypothesis Testing by Means of Meta-Analysis. *Oikos* **1998**, *83*, 212. [CrossRef]
58. Brito, C.; Dinis, L.-T.; Silva, E.; Gonçalves, A.; Matos, C.; Rodrigues, M.A.; Moutinho-Pereira, J.; Barros, A.; Correia, C. Kaolin and salicylic acid foliar application modulate yield, quality and phytochemical composition of olive pulp and oil from rainfed trees. *Sci. Hortic.* **2018**, *237*, 176–183. [CrossRef]
59. Brito, C.; Dinis, L.-T.; Luzio, A.; Silva, E.; Gonçalves, A.; Meijón, M.; Escandón, M.; Arrobas, M.; Rodrigues, M.A.; Moutinho-Pereira, J.; et al. Kaolin and salicylic acid alleviate summer stress in rainfed olive orchards by modulation of distinct physiological and biochemical responses. *Sci. Hortic.* **2019**, *246*, 201–211. [CrossRef]
60. Aly, M.; El-Megeed, N.A.; Awad, R.M. Reflective particle films affected on, sunburn, yield, mineral composition and fruit maturity of 'Anna' apple (*Malus domestica*) trees. *Res. J. Agric. Biol. Sci.* **2010**, *6*, 84–92.
61. El-Gioushy, S.F.; Baiea, M.H.M.; Gawad-Nehad, A.; Amin, O.A. Influence of $CaCO_3$ and green miracle foliar application on preventing sunburn injury and quality improvement of Keitt mango fruits. *Middle East J. Agric. Res.* **2017**, *6*, 1098–1110.